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1855-1930

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# FISH & RICHARDSON P.C.

October 12, 2000

Attorney Docket No.: 09375-006004

**Box Patent Application**  
Commissioner for Patents  
Washington, DC 20231

Presented for filing is a new divisional patent application of:

Applicant: GARY A. FREEMAN AND DAVID H. FREEMAN

Title: WEARABLE DEVICE

The prior application is assigned of record to Viztec, Inc., a Delaware corporation, by virtue of an assignment submitted to the Patent and Trademark Office and recorded on March 27, 2000 at 010715/0650.

Enclosed are the following papers, including those required to receive a filing date under 37 CFR §1.53(b):

	<u>Pages</u>
Specification	19
Claims	5
Abstract	1
Declaration (Unsigned)	2
Declaration (Signed)	2
Drawing(s)	13

Enclosures:

- Preliminary amendment, 2 pages.
- Postcard.

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Page 2

This application is a divisional (and claims the benefit of priority under 35 USC 120) of U.S. Application Serial No. 09/360,435, filed July 26, 1999, which is a continuation-in-part of U.S. Application Serial No. 09/103,481, filed June 24, 1998, now U.S. Patent No. 5,931,764. The disclosure of the prior application is considered part of (and is incorporated by reference in) the disclosure of this application.

The filing fee, based on the claims as presented in the preliminary amendment being filed herewith, is as follows:

Basic filing fee	\$355
Total claims in excess of 20 times \$9	\$0
Independent claims in excess of 3 times \$40	\$0
Fee for multiple dependent claims	\$0
Total filing fee:	\$355

This application is entitled to small entity status. Such status is still proper from the parent application.

A check for the filing fee is enclosed. Please apply any other required fees or any credits to deposit account 06-1050, referencing the attorney docket number shown above.

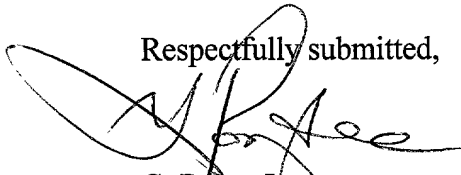
If this application is found to be incomplete, or if a telephone conference would otherwise be helpful, please call the undersigned at (617) 542-5070.

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Please send all correspondence to:

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Respectfully submitted,



G. Roger Lee  
Reg. No. 28,963  
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Gary A. Freeman et al.  
Serial No. :  
Filed : October 12, 2000  
Title : WEARABLE DEVICE

Art Unit : Unknown  
Examiner : Unknown

Commissioner for Patents  
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Prior to examination, please amend the application as follows:

In the Specification:

On page 1, line 5, after "application", insert --is a divisional of U.S. Application Serial No. 09/360,435, filed July 26, 1999, which--.

In the Claims:

Cancel claims 1-12 and 18-39.

09375-006004

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Applicant : Gary A. Freeman et al.  
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Page : 2

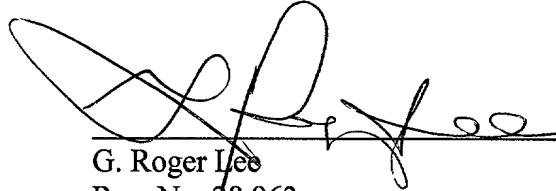
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Date: 10/12/00

  
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**APPLICATION**  
**FOR**  
**UNITED STATES LETTERS PATENT**

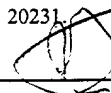
**TITLE:**                    **WEARABLE DEVICE**

**APPLICANT:**           **GARY A. FREEMAN**  
                              **DAVID H. FREEMAN**

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Jason DelThomas

WEARABLE DEVICE

Reference to Related Applications

5           This application is a continuation-in-part of  
allowed U.S. Application, Serial No. 09/103,481, filed on  
06/24/98, which is incorporated by reference herein.

Background of the Invention

10           Recently, watches and other wearable devices have  
begun to offer functions beyond simple display of the time.  
For example, some watches have incorporated keyboards and  
offer the ability to store and retrieve information such as  
addresses and phone numbers. These devices, however, remain  
housed in rigid and sometimes bulky housings. For an active  
15   user, such as a jogger, even the relatively minor bulk of a  
conventional wristwatch can be an annoyance.

Summary of the Invention

20           In general, in one aspect, the invention features an  
article of clothing constructed from one or more materials  
that includes a flexible display element attached to the one  
or more materials of the article of clothing and control  
circuitry connected to the flexible display element.

25           Embodiments may include one or more of the following  
features. The flexible display element may be permanently  
attached to the one or more materials. The flexible display  
element may be sewn to the one or more materials. The  
flexible display element may be adhesively attached to the  
one or more materials. The article of clothing may be a  
shoe, a hat, pants, a belt, or a wireless communication  
30   element.

          In general, in another aspect, a wearable article of  
clothing includes a flexible strap configured and sized to

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secure onto a wearer. The flexible strap includes a holographic layer substantially covering the strap's visible exterior.

Embodiments may include one or more of the following features. The holographic layer may be a holographic image of leather and metal. The article may include a display element connected to the strap and circuitry connected to the display element for controlling the display presented by the display element. The display element may include a flexible display element.

In general, in one aspect, a wearable device includes a display element, display control circuitry connected to the display element, and a flexible body for supporting the display element. The body is configured and sized to secure onto a wearer and includes one or more components for maintaining a configuration imparted by a wearer.

Embodiments may include one or more of the following features. The component(s) may be a wire. The component(s) may be a series of rigid components connected via a cup-and-ball arrangement. The display may be a flexible display. The device may include a wireless communication element, and at least one input control. The device may be a personal digital assistant and/or a video game system.

In general, in one aspect, the invention features a wearable device that includes a flexible display element, circuitry connected to the flexible display element for executing instructions that control the display presented by the flexible display element, and a flexible body configured and sized to secure the wearable device onto a wearer.

Embodiments may include one or more of the following. The device may additionally include at least one input control. The input control may be a directional input control (e.g., a joystick). The input control may be a

microphone. The instructions may include instructions for personal digital assistant software, a timer, an electronic game, a wireless communicator such as a pager or cellular receiver, and/or a remote control.

5           The device may also include a sensor. In these embodiments the device can include instructions for collecting and storing physiological data of the wearer.

Advantages can include one or more of the following.

10           Incorporation of the flexible display element and circuitry into articles of clothing provide the wearer with a comfortable, lightweight, portable device for viewing images and/or data.

15           Including a holographic layer (e.g., the strap) can give the device the appearance of a different material while remaining lightweight and comfortable.

20           The device can include materials or mechanisms that allow the wearer to remove the device from the wearer's body and place the wearable device on a surface or attach the wearable device to an object for more convenient and ergonomic viewing of the device display.

          Use of a wireless joystick in conjunction with the wearable device provides a wearer with an easy mechanism for providing directional control to programs executing on the wearable device.

25           Other features and advantages of the invention will be apparent from the following detailed description, and from the claims.

#### Brief Description of the Drawings

30           FIG. 1 is a diagram of a wearable device with a flexible display element.

          FIG. 2A is a cross-sectional view of the wearable device shown through cross section A-A of FIG. 1.



FIG. 2B is a cross-sectional view of the wearable device shown through cross section B-B of FIG. 1.

FIG. 3 is a circuit block diagram of display components.

5 FIG. 4 is a diagram of input keys.

FIG. 5 is a block diagram of device components.

FIG. 6 is a diagram of a sample display.

FIG. 7 is a diagram of a kickstart circuit that can control device power.

10 FIG. 8 is a diagram of a regulator and charge control for recharging a power source.

FIG. 9 is a diagram of a barrier strip layered over the flexible display element to provide stereoscopic effects.

15 FIG. 10 is a diagram of a multi-color display.

FIG. 11 is a diagram of a sample display produced when the wearable device executes personal digital assistant instructions.

20 FIG. 12 is a diagram of a sample display produced when the wearable device executes instructions for communicating.

FIG. 13 is a diagram of a wearable device.

FIG. 14 is a diagram of a wireless joystick.

FIG. 15 is a block diagram of the wireless joystick.

25 FIGS. 16-17 are diagrams illustrating mounting of the wearable device.

FIG. 18 is a diagram of a shoe including a flexible display.

30 FIG. 19 is a diagram of a hat including a flexible display.

#### Description of the Preferred Embodiments

Referring to FIG. 1, a wearable device 10 includes a flexible display element 12 and a strap 22 that forms the body of the device 10. The strap 22 can secure the device 10 around a person's wrist. Differently sized straps 22 can  
5 secure the device 10 around other body parts such as an ankle, leg, or finger, or around an inanimate object. The device 10 incorporates lightweight, flexible components that enable the device to conform to a given contour and offer a slim profile. The device 10 may safely undergo flexing of  
10 the type and magnitude normally experienced by watches, anklets, etc. during physical activity.

As shown, the strap 22 has an overmolded, flexible polymer (e.g., polyurethane) buckle 24. Strap holes 23  
15 slide into the buckle under buckle 24 rails. A molded ramp 25 provides a latching mechanism that engages the holes. Pulling the strap 22 radially away from the wrist releases the strap 22 from the buckle 24. Alternatively, the strap 22 could use velcro, a peg and hole mechanism, or other fasteners.

20 The device 10 can present information via the flexible display element 12 and a thin-film flexible piezoelectric speaker 21 that offers multiple-octave sound. U.S. Patent No. 5,115,472 to Park describes a flexible piezoelectric speaker/microphone made of polymer films, and is  
25 incorporated herein. The device 10 can receive information via input keys 18. The piezoelectric speaker/microphone 21 also enables the device 10 to receive sound information. Thus, a user can speak into the device 10, for example, to record speech or use the device as a communication device.

30 The device 10 can communicate with external devices, such as computers and smart card readers, via a communication element 16. The communication element 16 may be a wireless inductive loop screen-printed within the body

of the device 10. The communication element 16 can enable the device 10 to process RF communication such as cellular messaging service communication, GPS (Global Positioning System) signals, and paging signals.

5 Alternately, the communication element 16 may take the form of shielded electrical contacts. As the device 10 may be narrower than a smart card, a passive mechanical adapter may be needed to connect the device 10 to a smart card reader if the device 10 uses a contact communication element  
10 16.

The device 10 may include a power source 14 such as a flexible thin-film lithium battery, such as Oak Ridge National Laboratories' thin-film battery. The flexible display element 12, however, does not require a power source  
15 to produce a static display.

Referring to FIGS. 2A and 2B, the device 10 includes protective top 26 and bottom 28 layers and inner separator 27. The top layer 26 covers the display element with a transparent material such as PVC or clear plastic. The top  
20 26 and bottom 28 layers may otherwise be constructed from a flexible polymer such as polycarbonate. Other embodiments can use plastic, paper, reinforced paper, cardboard, polyvinyl chloride, polyester, or ABS as layer material. Portions of the top 26 and bottom 28 layers may include  
25 printed indicia.

The device 10 can include a flexible holographic layer 29, for example, by using flexible holographic strips produced by Krystal Holographics International Inc. The layer 26 can cover all or any portion of the visible  
30 exterior of the strap excluding the flexible display. The holographic image presented by holographic layer 29 can make the strap appear to be made of a material such as leather or metal. This can allow the strap to appear to be a metal

band while having the advantage of weight substantially less than a band that is actually made of metal.

In some embodiments, the holographic layer can be easily removed from the wearable device and replaced with a different holographic layer. For example, the holographic layer edges may be forced between edges of the polymer edging 20 for easy removal and insertion of different holographic layers. The soft edging 20 adds comfort to a wearer. Additionally, in some embodiments the edging 20 waterproofs the assembly.

Layers 26 and 28 may be molded or machined into the necessary shape to accommodate internal components. The internal components can include an integrated circuit 39 mounted above a printed circuit board 36. The integrated circuit 39 can offer a variety of functions ranging from providing simple digital clock to processing video graphics information. The integrated circuit 39 may include a microprocessor 40. The size of the integrated circuit 39 and printed circuit board 36 is exaggerated in the cross-sectional view of FIG. 2B.

In some embodiments circuitry is provided by an organic semiconducting layer such as the layer described in Low-Voltage Organic Transistors on Plastic Comprising High-Dielectric Constant Gate Insulators, Science Vol. 283, 5 February 1999.

The flexible display element 12 can be made from a variety of materials. In one implementation, transparent electrodes 30 (indium tin oxide or other substantially clear conductive material) are deposited on the interior surfaces of the top 26 and bottom 28 layers. The electrodes may be configured to provide either a dot matrix pattern or a segmented display pattern. Z-axis conductor 34 (known polymeric material with conductivity only in the Z axis)

provides conductive paths from the printed circuit board to the electrodes which fork into electrode layers 19a and 19b that appear in the top 26 and bottom 28 layers.

5 The electrodes work in conjunction with liquid crystal display (LCD) film 32, which is a bi-stable or multi-stable display material that will maintain an image when power has been removed. In this way, it is unnecessary for the device 10 to have its own power source, or be connected to a power source, for the display to function. The preferred LCD material is a ferroelectric LCD. These LCDs are based on 10 smectic liquid crystals typically of the smectic C phase with chiral behavior. When formed in a thin layer the ferroelectric material has a net polarization that is perpendicular to the viewing surface. The electrodes apply 15 a field that rotates polarization between an "on" and an "off" state. Ferroelectric LCDs are typically sensitive to shock or bending, making them unsuitable for use in a display element 12 that can be bent and flexed. To make the ferroelectric LCD less sensitive to bending, the 20 ferroelectric liquid crystal (FLC) is fixed to a side-chain of the polymer used to create the LCD film (e.g., as taught in Japanese Patent Document No. 63-318526) or where the FLC is dispersed in the polymer film (e.g., as taught in U.S. Patent No. 5,638,194). As a result, the display can display 25 information while in the flexed position (e.g., when strapped around a wearer's wrist).

The display of the wearable device may safely undergo "flexing of the type and magnitude experienced during normal use and handling." For example, when worn around a wrist, 30 finger, or ankle the display may deflect considerably (e.g., 1 or 2 cms).

The display may not function perfectly, or at all, while the display is flexed into a curved shape, but once

the display is allowed to assume its original shape it will again function correctly. Contributing to this flexibility are the polymer substrates (top and bottom layers) and the z-axis conductor for making connections between the printed circuit board and the display. The z-axis conductor can withstand the variable compression that flexing produces.

Other implementations can include different display elements such as suspended particle displays or light emitting polymer displays. These display elements, however, require a power source to display images.

Referring to FIG. 3, the microprocessor 40 of the integrated circuit 39 controls a driver circuit 42, which develops the voltages appropriate to activate and deactivate the display element pixels. The display driving circuitry can use a multiplexed technique used in commercial passive displays to quickly refresh the display. A power source in the device 10 or an external power source (e.g., a smart card reader) can provide the power needed by the microprocessor 40 and other stages. Polarity switcher 44 at the output of the driver circuit selects whether the row or column electrode is to receive the positive polarity. Row/column selector switch determines which specific row/column pair receives the voltages produced by the polarity switch and driver circuit. Microprocessor 40 controls the driver circuit 42, polarity switcher 44, and row/column selector switch 46. Contributing to display flexibility are polymer substrates (top and bottom layers) and the z-axis conductor for making connections between the printed circuit board and the electrodes 19. The z-axis conductor can withstand the variable compression that flexing produces.

The microprocessor 40 can also display a graphic image or a series of graphic images to produce animation sequences

on the display element 12 by retrieving and displaying different stored image information. The images may form a video or slide-show.

Referring to FIG. 4, the device 10 can receive input via input keys 18. Preferably, the input keys 18 are conductive concave "dome switches" laminated between the top and bottom layers of the device 10. Localized areas directly under the dome switches are internally laminated with a rigid material to increase the reliability of the switches and improve tactile feedback. Pressing a dome switch 18 completes an electric connection which the integrated circuit 39 senses for closure. The connection occurs over circuits screen-printed onto the bottom layer with conductive inks.

Referring to FIG. 5, the microprocessor 40, powered by a power source 14, controls device 10 functions. In addition to communication element 16, input keys 18, and microphone 21, the microprocessor 40 can receive input from sensors 60 that physiologically monitor a wearer of the device 10. For example, a piezoelectric polymer film such as poly vinylidene fluoride (PVDF) can acoustically collect different physiological data such as a wearer's heart rate. Other sensors can detect electrical energy, thus collecting electrocardiographic (ECG) data. The collected data can be displayed and/or stored for future download providing medical care providers with information about heart rate, abnormal heart rhythms, etc. The device 10 could also incorporate sensors such as an accelerometer to collect and display pedometer data.

The microprocessor 40 not only drives the display 12 but can also support multiple applications. For example, an application can provide compatibility with different smart card communication protocols. This feature enables the

device 10 to offer smart card functions. One of the most common functions of smart cards today is as a stored-value card, which contains monetary value in an embedded microchip. Other smart card functions include providing  
5 access to ATM machines, GSM (Global System Management) cellular phones, television set top boxes, PC based applications such as internet chip card payment systems, screen phones, pay telephones, stored value systems (sometimes referred to as an "electronic purse"), public  
10 transportation systems, health insurance and health care provider systems, government benefit programs, and loyalty systems such as retailer frequent shopper.

Runners, who often prefer not to carry money or other forms of identification while jogging, can use the device as  
15 a timer, identification, a physiological monitor, and as a mechanism for paying for goods and services at the growing list of venues that offer smart card service. When the exercise session is completed, a jogger could download the collected data (e.g., heartrate) to a personal computer  
20 which could track and display the data over a long period of time.

Health care providers can use the wearable device 10 to affix patient information to a patient without discomfort. The device 10 might store and display medication and medical  
25 condition information. Quick access to such information could be critical in deciding what emergency treatment to give a patient.

The microprocessor 40 may also control a wireless communication element 16 to handle cellular messaging or  
30 paging services. For example, the device 10 can receive RF Short Message Service message and display the information described by the message on the display 12. Additionally, the microprocessor 40 can coordinate reception and



transmission of wireless communication, for example, by acting as a cellular phone.

The microprocessor 40 may also handle applications such as Java applets. Applications may include compression/  
5 decompression programs that reduce the amount of information communicated.

Referring to FIG. 6, the flexible display element 12 may present a wearer with information that includes the wearer's heart rate 48 as sensed by device sensors, a  
10 stopwatch indicator 50, a pedometer 52, the current time 54, a balance of "smart card" money 56 retained in the device, and other information.

Referring to FIG. 7, as mentioned, in the preferred embodiment, the device 10 may include a power source 14.  
15 While the device 10 consumes little power, the device 10 can provide several methods of conserving energy. A kickstart circuit 70 (e.g., a flip-flop 70 that controls power source 14) connected to a user controlled contact area (e.g., one of the input keys) can control power consumption. Pressing  
20 a contact area causes the kickstart circuit 70 to initiate power output from the power source 14. The kickstart circuit can provide power for a pre-determined time period or until a subsequent pressing of the contact area. In another implementation, the contact area could instead  
25 merely connect otherwise disconnected wires to draw power from the power source 14. This later implementation requires continual pressure on the contact area to draw power. As mentioned, the display element does not need power to display a static image when the power source does  
30 not deliver power. A contact area 58 can control other functions, for example, clearing the display element.

Recharging the power source 14 can be performed in a variety of ways. As shown in FIG. 8, the device 10 could

include a regulator charge control circuit 74 that accepts current and voltage from an external power source (e.g., a smart card reader) via contacts for storage in a battery 14. A wireless device can recharge a power supply 14 from communication signals boosted to both transmit information and power.

Referring to FIG. 9, the display 12 can offer stereoscopic effects such as images that appear three-dimensional and images that alter their appearance based on viewing angle (e.g., a face that winks as a viewer moves the display). For example, an LCD barrier strip 80 (described in U.S. Pat. No. 5,315,377 to Isono, incorporated by reference) intersperses vision blocking barrier regions with viewing regions to control the image perceived by a viewer. By choosing appropriate underlying LCD image, the barrier strip 80 alters image appearance. As shown in FIG. 9, left eye 76 sees point A, but not point B, while right eye 80 sees point B, but not point A.

Referring to FIG. 10, a filter layer 88 can add color to an otherwise monochromatic LCD display. The filter layer 88 may include color filters for red, green, and blue. A pixel 86 either blocks color filtered light or permits the color to illuminate a pixel 86. Though each pixel 86 only shows red, green, or blue, the viewer spatially integrates the colors to perceive combinations of the above colors (e.g., purple).

Referring to FIGS. 11 and 12, the wearable device can have the same physical exterior and internal components whether being used as a pager, personal digital assistant, cell phone, game, pedometer, or a combination thereof. The flexible display element 12, however, can present a display based on the function being performed by the device. For example, the device can execute personal digital assistant

(PDA) software instructions that perform functions such as displaying and storing calendar and scheduling information, storing entered notes, and maintaining an electronic address book. When executing personal digital assistant software  
5 instructions, the flexible display element 12 can present a display that includes a pull down menu 101, list field 102, and dialog menu box 104.

As shown in FIG. 12, when being used for communication (e.g., when acting as a cellular phone or pager), the  
10 flexible display element 12 includes information such a signal strength indicator 106, a message field 108, a battery power indicator 110, a phone name list softkey 112, and a menu function softkey 114.

Referring to FIG. 13, a wearable device 10 can be used  
15 to provide a portable electronic game system. For example, the processor can execute instructions for different video games (e.g., electronic card games, arcade games and electronic pets). The games can be loaded from a smart card 128. The smart card 128 can also be used to store scores  
20 and/or character data. The instructions can also be loaded via a wireless communication element 16. Different input controls (e.g., wireless joystick 144) permit users to interact with the video games. For example, in a shooting-type game, keying elements (not shown) can indicate  
25 the positive and negative directions on two axes. A fifth keying element can be used as a shooting trigger. The communication element 16 may be an infrared serial link (e.g., link using the IrDA Infrared standard) used to exchange information with another game device allowing two  
30 or more users to play each other. The device 10 can also communicate with video arcade machines and/or PCs. For example, gaming character definitions stored on the wearable device can be downloaded to a different video game machine

and the user could play the arcade version with additional powers and self-defined characters. The appearance of the device can be tailored for different games. For example, the device exterior can be colored, have holographic layers, or sculptural elements corresponding to a particular game.

The device 10 can also act as a remote control. For example, the display can show volume and channel information. By interacting with the device, the wireless control can transmit remote control signals to a TV, VCR, or other component. The device 10 can also be used to receive and display television signals or a series of static images such as book or magazine pages.

In some embodiments, the device 10 is constructed so that the flexible display 12 wraps around a user's hand. This embodiment permits use of a larger display 12 which may be preferred for use of the device as a TV, personal digital assistant (PDA), video game, or device for listening to and viewing music videos. As shown, the device 10 includes a display subassembly 142 and a battery/processor subassembly 134. The device 10 can receive user input from one or more input controls 144.

The display subassembly 142 includes a flexible display 12 overmolded into a flexible plastic 22. The display subassembly 142 is constructed to wrap around a user's hand. For example, as shown, a user can insert their thumb into the thumbhole 140 and strap the display assembly 12 around their hand using snaps or Velcro (not shown). A flexible cable 122 connects the display subassembly 142 to display driver electronics included in the battery/processor subassembly 134.

The battery/processor subassembly 134 includes a battery compartment 132, a smart card connector 130 for interfacing with a smartcard 128, processor electronics

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(e.g., a printed circuit board (PCB)), a wriststrap 126, a speaker 136, and communication element (e.g., an infrared transceiver, a wireless inductive loop, or antenna) 16. The device 10 can communicate with external devices such as  
5 computers and smart card readers.

Referring to FIG. 14, the device can receive input from an input control 144 such as a directional input control. For example, the input control 144 can be a wireless free-floating joystick. The joystick 144 includes a  
10 solid-state accelerometer 148, 150 (e.g., an Analog Devices™ ADXL202) which is capable of distinguishing and measuring accelerations along one or two orthogonal axes in a plane or planes of motion. Thus, a user can provide directional input (e.g., up, down, left, and right) by simply moving their  
15 hand.

Referring to FIG. 15, the free-floating joystick 144 includes a knob 146 connected to a combined rotary encoder/switch 166. Rotating the knob 146 causes the rotary encoder 166 to provide rotational position information which  
20 can be processed by software or hardware instructions to scroll through screens, etc. The encoder 166 feeds two signals to a joystick microprocessor 160. Each signal is composed of a pulse train whose phase is shifted 90 degrees from the other signal (quadrature signals). The switching  
25 rate of the two signals is directly related to the angular rotational rate of the knob 146 and the rotational direction determines the relative phase of the two signals. Thus, the direction and degree of rotational movement of the knob 146 is completely defined by the quadrature signals. Pressing  
30 the knob 146, similar to clicking a ballpoint pen, activates a switch providing another input signal for different applications (e.g., selecting user interface elements or shooting a weapon in a game). Embedded in the joystick 144

is a radio-frequency inductive loop antenna 158 for providing both power to the joy-stick and communicating with the battery/processor assembly 134 or other host-system. The battery/processor assembly 134 can include a corresponding  
5 inductive loop embedded in the display subassembly in a location that results in the two inductive loops being placed adjacent to each other when the joystick is held in the user's hand. The joystick 144 may, alternatively, contain its own battery as part of the power supply 154 which allows  
10 for communication between the joystick 144 and the battery/processor assembly 134 at distances of at least three feet. This allows the user to operate the joystick 144 with a hand not wearing the wearable device. The joystick may also include user input switches (e.g. buttons) along its  
15 surface.

The joystick 144 includes a microprocessor 160 for detecting closure of additional switches 162 (e.g., buttons along the length of the joystick 144 exterior), determining rotary encoder 166 position, and processing information from  
20 the accelerometer 150, and the antenna 158 via RF electronics 156. The microprocessor 160 integrates this information into a data format for serial transmission via the antenna 158. The components of the joystick are preferably mounted on an internal PCB.

Referring again to FIG. 13, the device 10 can receive input from a variety of sources in addition to or in lieu of the joystick. In other embodiments, the device 10 can receive user input via flat piezoelectric force-sensors which detect the direction of force. The piezoelectric directional  
30 control element can be put on a wearable element much like a thumb-cap that can be inserted over the wearer's finger.

In another embodiment, the input control can be a small detachable keypad with four directional keying elements

indicating positive and negative directions along two typically orthogonal axes along with fifth and sixth keying elements.

In another embodiment the input control can be a  
5 "touch-sensitive pad" that provides directional control by determining the contact location on a flat area via measurement of either the electrical capacitance or resistance of lines organized in a typically X-Y grid.

Referring to FIGS. 16-17, the device 10 can include  
10 ductile materials or other mechanisms which hold the display 12 at a good viewing angle when removed from the wearer's body, placed on a tabletop or other surface, and molded into a particular shape. In one embodiment, the wearable device body 22 (e.g., strap) includes a wire 137 embedded in a  
15 thermoplastic. Fig. 16 shows the wire as being visible, however, in the preferred embodiment the wire is hidden by the device 10 exterior. The wire is preferably a ductile, heavy-gauge wire that retains a given shape imparted by a user. After removing the wearable device 10 from the  
20 wearer's body, the wearer can mold the device 10 into a stable shape that presents the display 12 at a comfortable viewing position. Fig. 16 shows the device 10 bent to present the display 12 at a comfortable viewing angle. Fig. 17 shows the device 10 wrapped around a chair arm to hold the  
25 display 12 steady when a flat surface is not available.

In other embodiments mechanisms or materials provide the ability to control the position of the display when the wearable device 10 is placed on a surface or object. For example, the device 10 body 22 may include a series of short,  
30 reticulated rigid elements connected to each other via a spring-loaded cup-and-ball arrangement much like the neck of a "snake-light".

Referring to FIG. 18, the flexible display 12 and circuitry can be included in articles of clothing. An article of clothing is typically constructed from one more different materials. For example, a sneaker 180 can include  
5 canvas, rubber, and/or plastic pieces connected and configured to accept a wearer's foot. As shown, the sneaker 180 also features the flexible display 12 and associated circuitry. The flexible display 12 can present physiological and pedometric (e.g., mileage 184 and duration  
10 186) information to a walker or jogger. The display can present advertisements, promotions, and company and/or product logos. The display can be included in a variety of locations on the shoe 180 such as the toe, heel, or side.

Referring to FIG. 19, the flexible display 12 and  
15 display control circuitry can also be included in a hat 188 (as shown) or other articles of clothing such as a belt, a shirt, or a pair of pants. Preferably, the flexible display 12 and circuitry can be permanently affixed to the article of clothing via sewing or a thermoplastic adhesive. The  
20 flexible display 12 can also be affixed temporarily via velcro or snaps.

Other embodiments are within the scope of the following claims.



What is claimed is:

1        1. An article of clothing constructed from one or more  
2 materials, wherein the improvement comprises:

3        a flexible display element attached to the one or more  
4 materials of the article of clothing; and

5        circuitry connected to the flexible display element,  
6 the circuitry controlling the flexible display element.

1        2. The article of clothing of claim 1 wherein the  
2 flexible display element is permanently attached to the one  
3 or more materials.

1        3. The article of clothing of claim 2 wherein the  
2 flexible display element is sewn to the one or more  
3 materials.

1        4. The article of clothing of claim 2 wherein the  
2 flexible display element is adhesively attached to the one or  
3 more materials.

1        5. The article of clothing of claim 1 wherein the  
2 article of clothing comprises a shoe.

1        6. The article of clothing of claim 5 wherein  
2 circuitry displays pedometric data on the flexible display.

1        7. The article of clothing of claim 1 wherein the  
2 article of clothing comprises a hat.

1        8. The article of clothing of claim 1 wherein the  
2 article of clothing comprises pants.



2 a display element;  
3 display control circuitry connected to the display  
4 element; and  
5 a flexible body for supporting the display element, the  
6 body being configured and sized to secure onto a wearer, the  
7 body including one or more components for maintaining an  
8 imparted configuration.

1 19. The device of claim 18 wherein the at least one  
2 component comprises a wire.

1 20. The device of claim 18 wherein the at least one  
2 component comprises a series of rigid components connected  
3 via a cup-and-ball arrangement.

1 21. The device of claim 18 wherein the display  
2 comprises a flexible display.

1 22. The device of claim 18 further comprising  
2 a wireless communication element, and  
3 at least one input control.

1 23. The device of claim 18 wherein the device  
2 comprises a personal digital assistant.

1 24. The device of claim 18 wherein the device  
2 comprises a video game system.

1 25. A wearable device, comprising:  
2 a flexible display element;  
3 circuitry connected to the flexible display element for  
4 executing instructions, the instructions comprising  
5 instructions that control the flexible display element;

6 a flexible body configured and sized to secure the  
7 wearable device onto a wearer.

1 26. The device of claim 25 further comprising at least  
2 one input control.

1 27. The device of claim 26, wherein the input control  
2 comprises a directional input control.

1 28. The device of claim 27, wherein the directional  
2 input control comprises a wireless joystick.

1 29. The device of claim 27, wherein the input control  
2 comprises a microphone.

1 30. The device of claim 25, wherein the instructions  
2 comprise instructions for personal digital assistant  
3 software.

1 31. The device of claim 25, wherein the instructions  
2 comprise instructions for an electronic game that receives  
3 input from the at least one input control and displays game  
4 graphics on the flexible display element.

1 32. The device of claim 25 wherein the device further  
2 comprises a wireless communication element.

1 33. The device of claim 32 wherein the devices  
2 comprises a pager.

1 34. The device of claim 32 wherein the device  
2 comprises a cellular receiver.

1        35. The device of claim 32, wherein the instructions  
2        comprise instructions for receiving messages via the  
3        communication element and displaying the messages on the  
4        flexible display element.

1        36. The device of claim 32, wherein the instructions  
2        comprise remote control instructions.

1        37. The device of claim 32 further comprising at least  
2        one sensor.

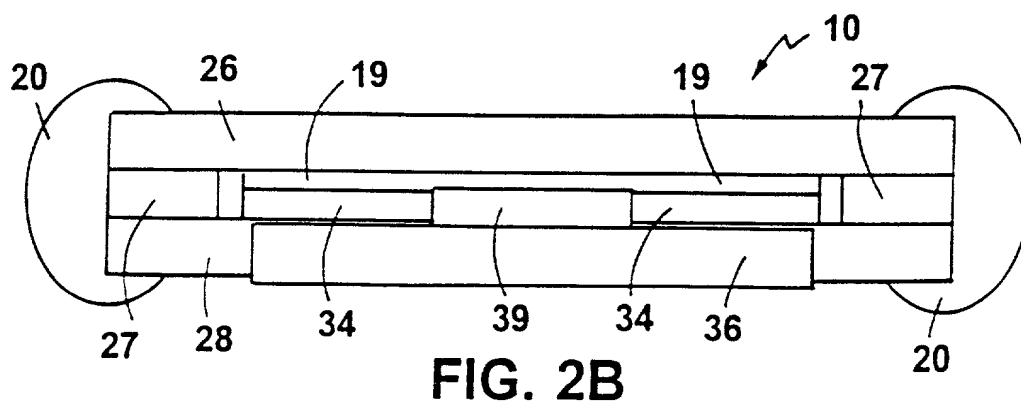
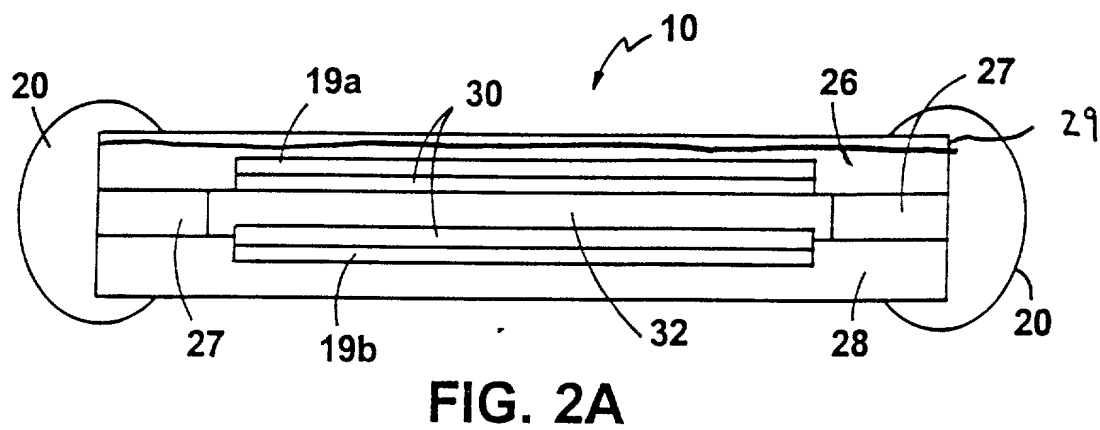
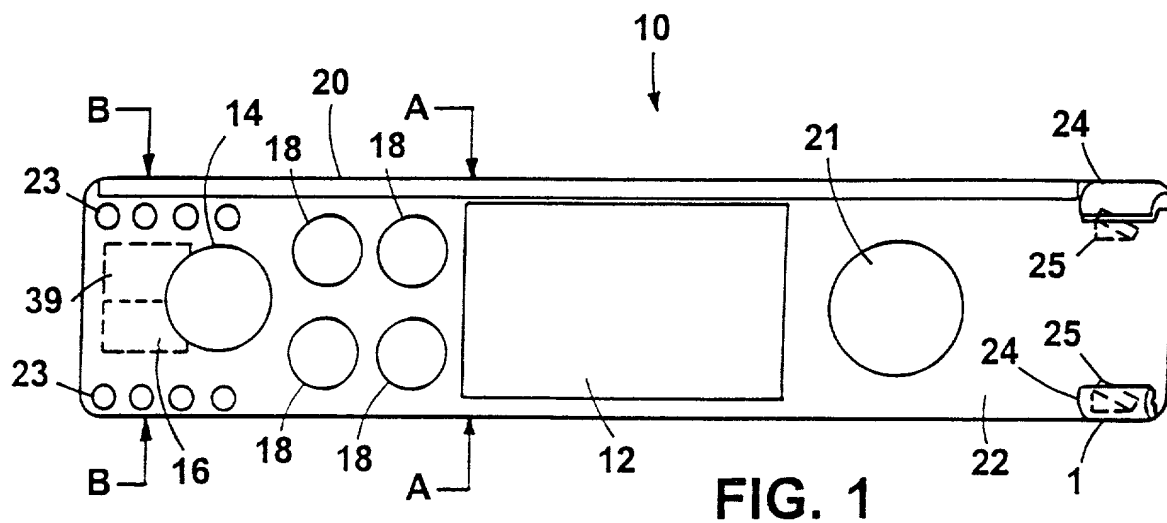
1        38. The device of claim 37 wherein the instructions  
2        comprise instructions for collecting and storing  
3        physiological data of the wearer.

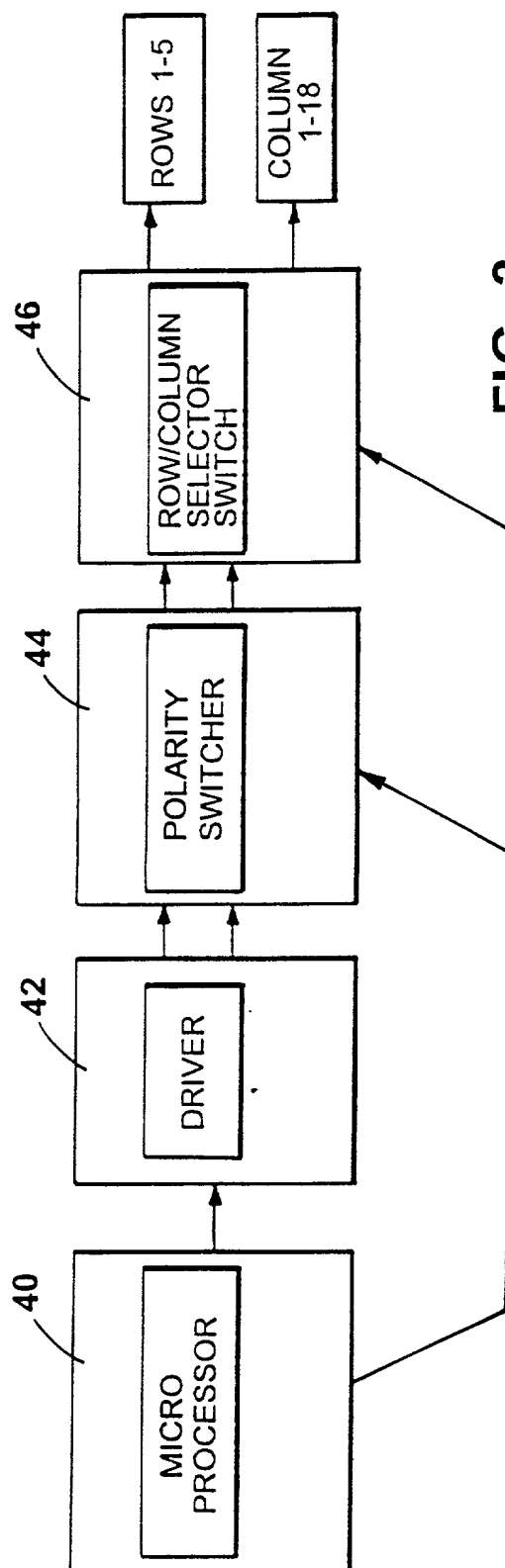
1        39. The device of claim 32 wherein the instructions  
2        comprise instructions for displaying time.

Abstract

An article of clothing constructed from one or more materials includes a flexible display element attached to the one or more materials of the article of clothing and circuitry for controlling the flexible display element.

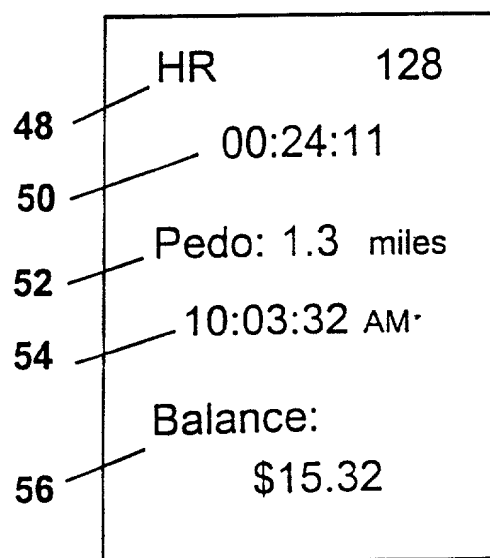
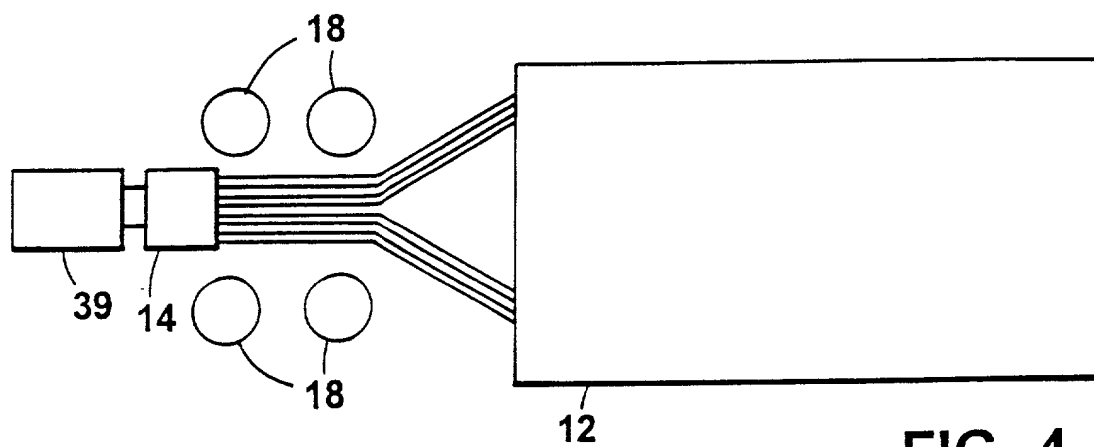
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**FIG. 3**





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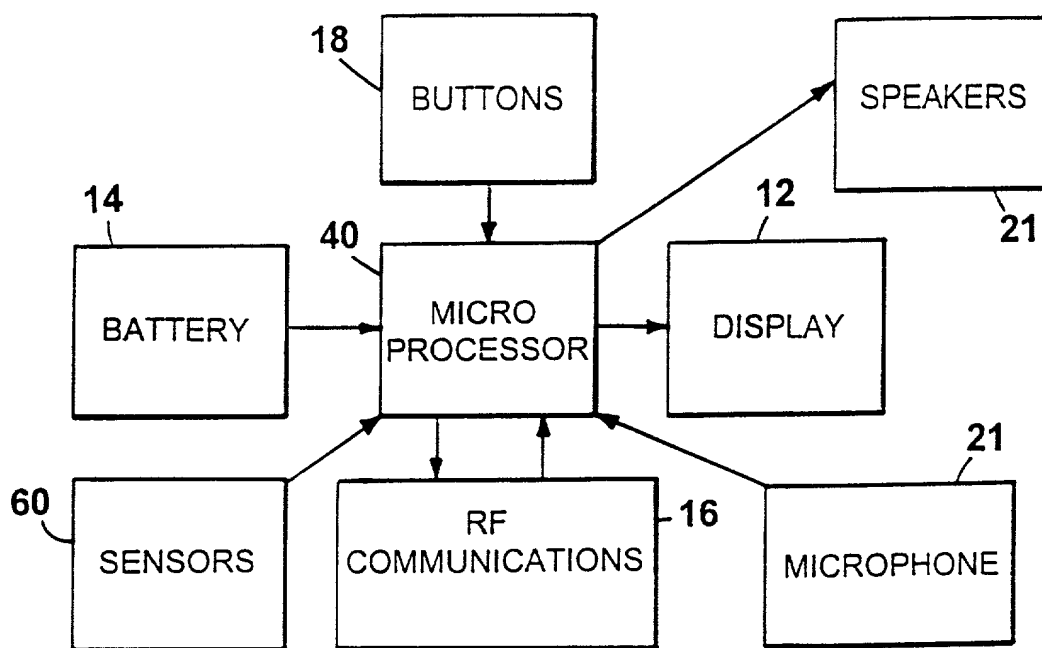


FIG. 5

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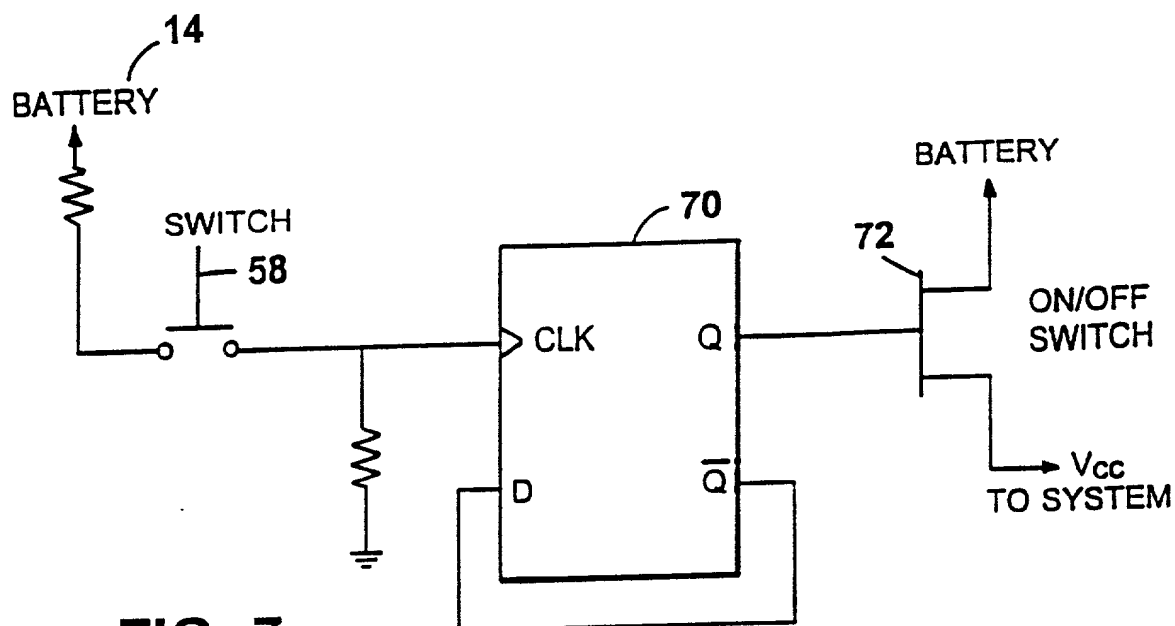


FIG. 7

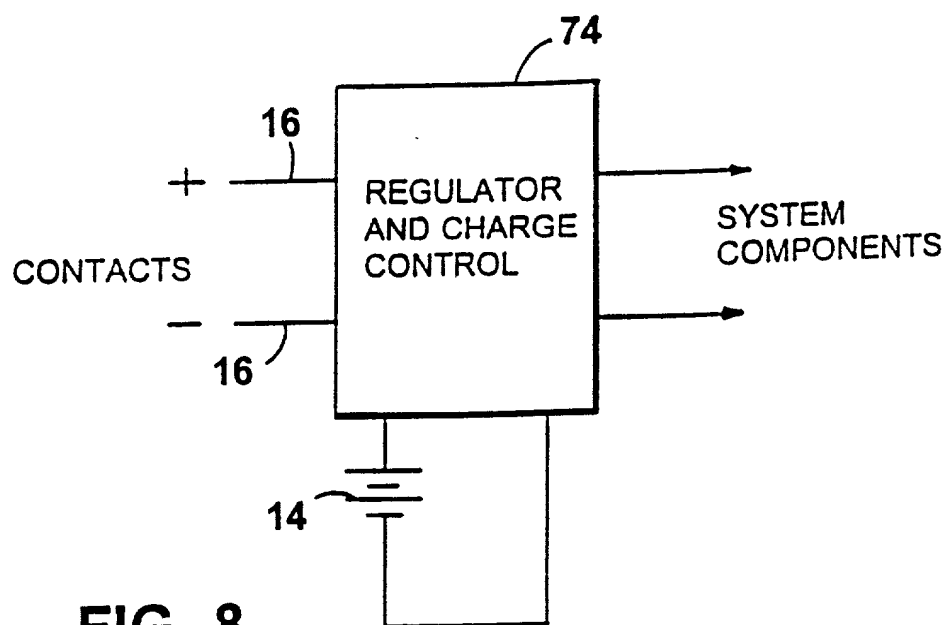


FIG. 8

Diagram illustrating the geometry of the eyes and the surface. The left eye (76) and right eye (78) are shown. A horizontal line (80) represents the line of sight. The surface (24) is shown below the line of sight. Points A and B are marked on the surface. The diagram shows the lines of sight from the eyes to the surface, illustrating the geometry of the system.

FIG. 9

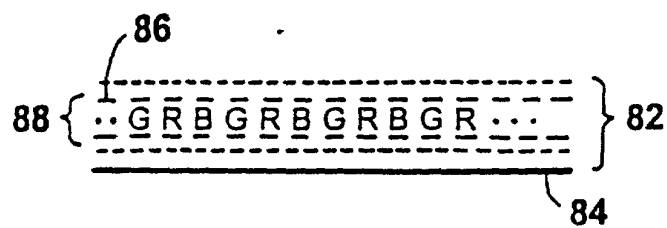


FIG. 10

12

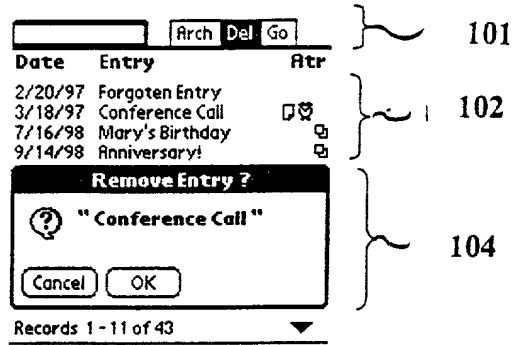


FIG. 11

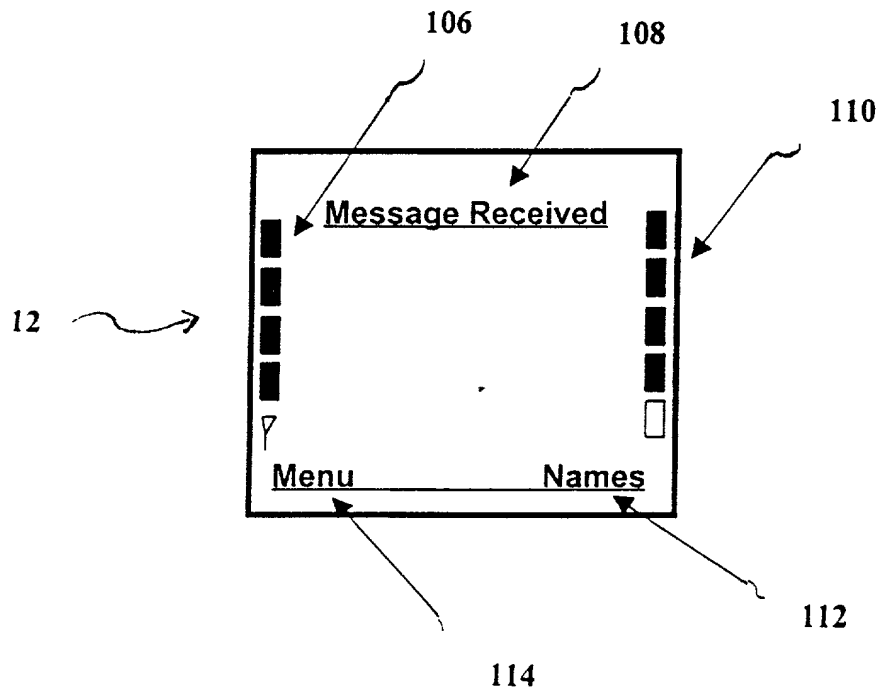


FIG. 12

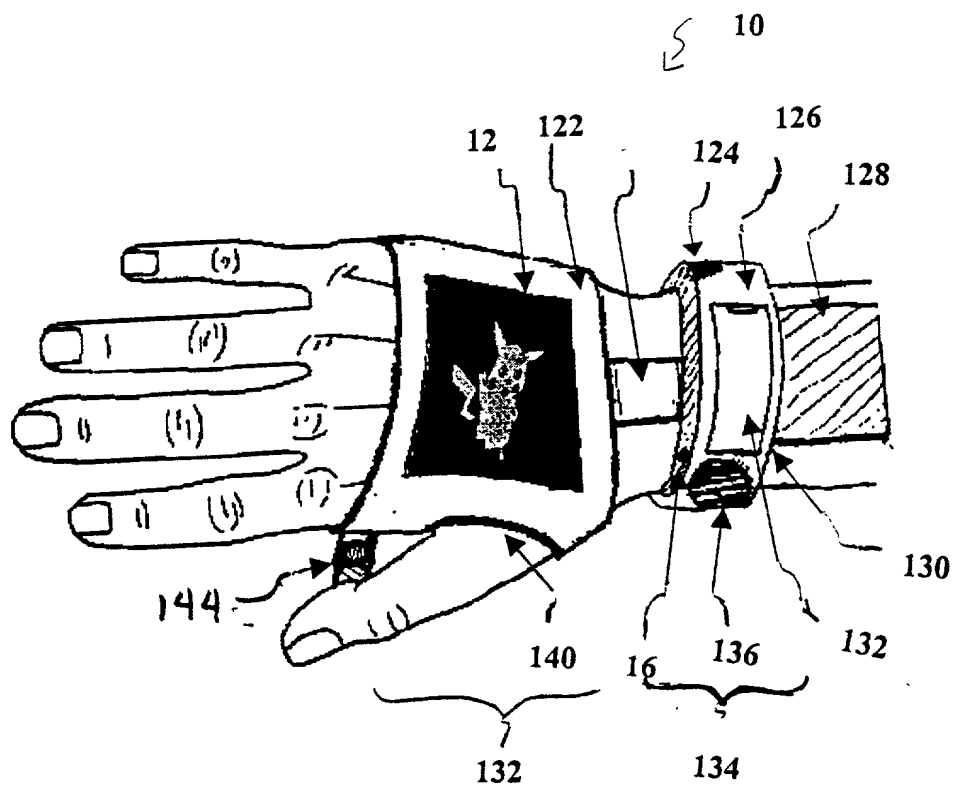


FIG. 13

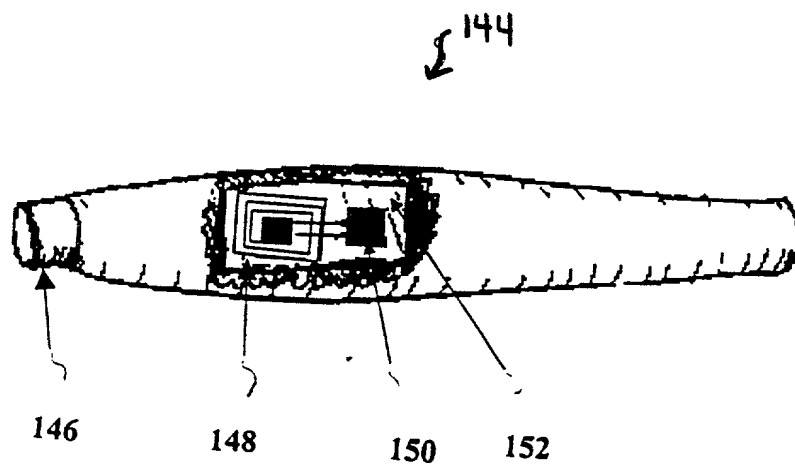


FIG. 14

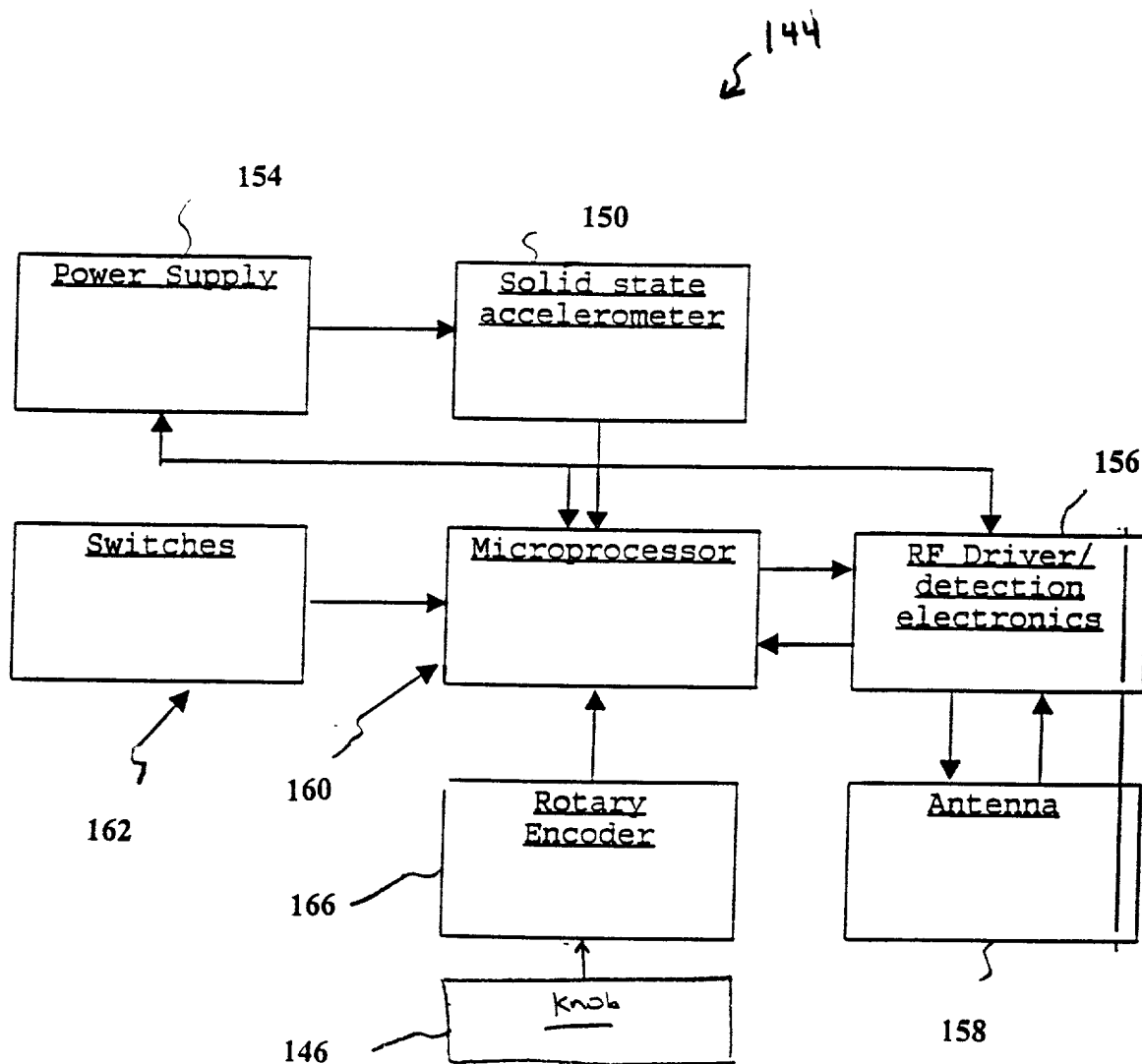


FIG. 15

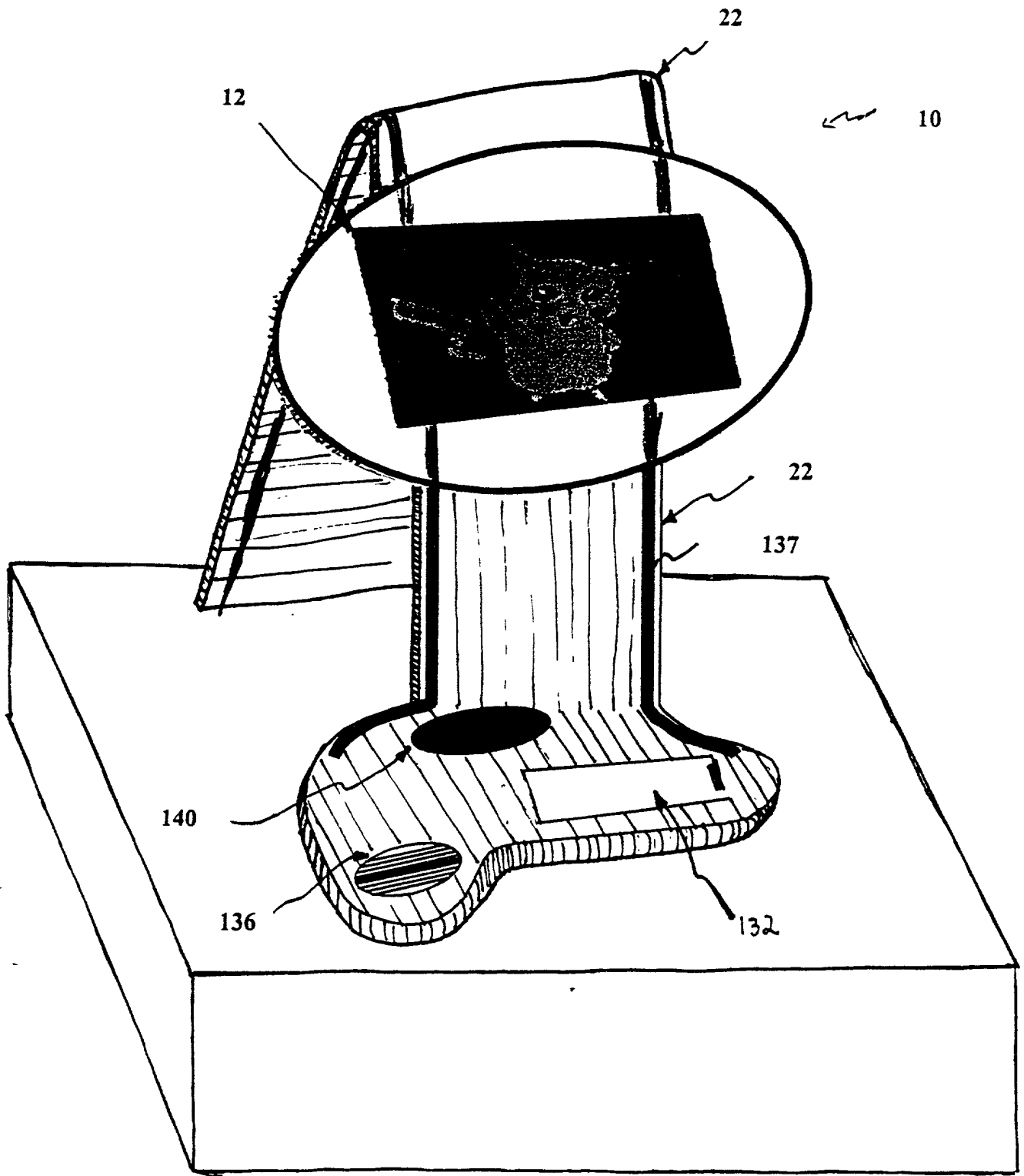


FIG. 16



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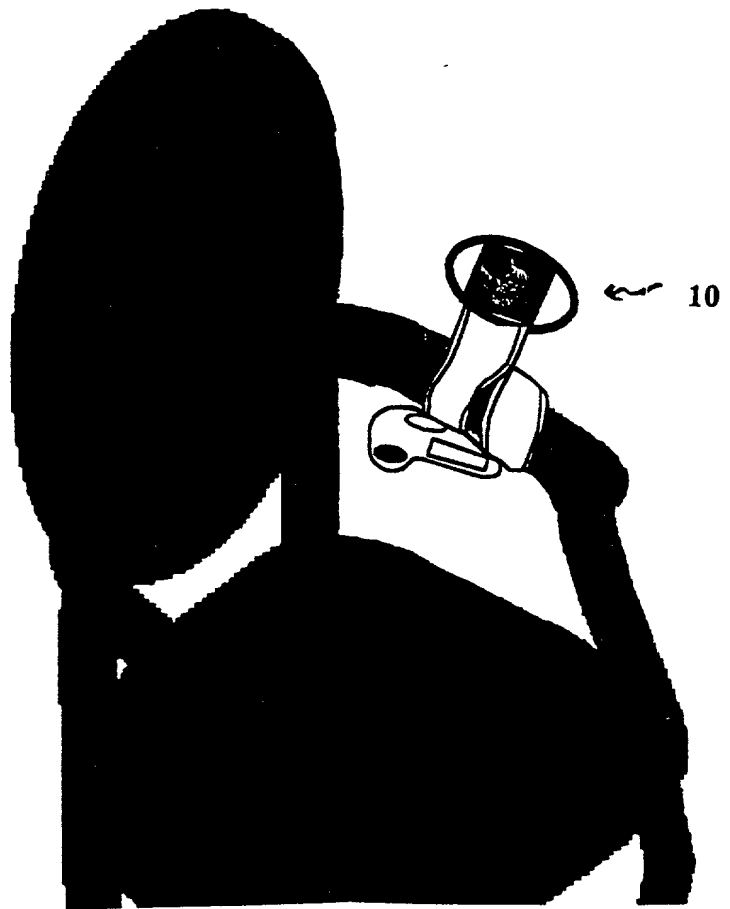


FIG. 17

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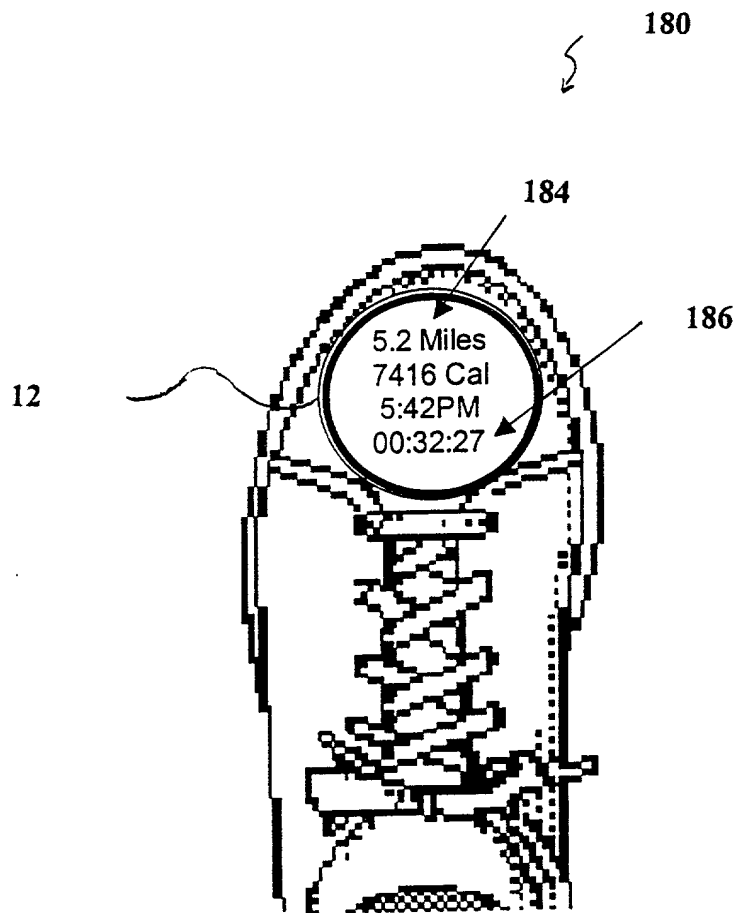


FIG. 18



FIG. 19

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled WEARABLE DEVICE, the specification of which

☒ is attached hereto.

☐ was filed on \_\_\_\_\_ as Application Serial No. \_\_\_\_\_ and was amended on \_\_\_\_\_.

☐ was described and claimed in PCT International Application No. \_\_\_\_\_  
filed on \_\_\_\_\_ and as amended under PCT Article 19 on \_\_\_\_\_.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information I know to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. SERIAL NO.	FILING DATE	STATUS
<u>09/103,481</u>	<u>March 24, 1998</u>	<input checked="" type="checkbox"/> Pending <input type="checkbox"/> Issued <input type="checkbox"/> Abandoned

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: G. Roger Lee, Reg. No. 28,963.

Address all telephone calls to G. Roger Lee at telephone number 617/542-5070.

Address all correspondence to G. Roger Lee, Esq., Fish & Richardson P.C., 225 Franklin Street, Boston, MA 02110-2804.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

Full Name of Inventor: Gary A. Freeman

Inventor's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Residence Address: 47 Stearns Street, Newton, MA 02159

Citizen of: United States

Post Office Address: 47 Stearns Street, Newton, MA 02159

# COMBINED DECLARATION AND POWER OF ATTORNEY CONTINUED

Full Name of Inventor: David H. Freeman

Inventor's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Residence Address: 13318 Golf Crest Circle, Tampa, FL 33624

Citizen of: United States

Post Office Address: 13318 Golf Crest Circle, Tampa, FL 33624

DECLARATION

**COMBINED DECLARATION AND POWER OF ATTORNEY**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled, the specification of which:

- ☐ is attached hereto.  
☒ was filed on July 26, 1999 as Application Serial No. 09/360,435 and was amended on \_\_\_\_\_.  
☐ was described and claimed in PCT International Application No. \_\_\_\_\_ filed on \_\_\_\_\_ and as amended under PCT Article 19 on \_\_\_\_\_.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, §119(e)(1) of any United States provisional application(s) listed below:

U.S. Serial No.	Filing Date	Status
-----------------	-------------	--------

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information I know to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. Serial No.	Filing Date	Status
09/103,481	March 24, 1998	Pending

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

Country	Application No.	Filing Date	Priority Claimed
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

G. Roger Lee, Reg. No. 28,963

00669305 "101200

## Combined Declaration and Power of Attorney

Page 2 of 2 Pages

Address all telephone calls to G. ROGER LEE at telephone number (617) 542-5070.

Address all correspondence to G. ROGER LEE at:

FISH & RICHARDSON P.C.  
225 Franklin Street  
Boston, MA 02110-2804

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

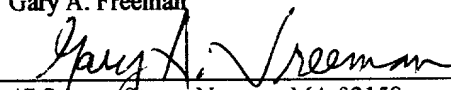
Full Name of Inventor: Gary A. Freeman

Inventor's Signature:

Residence Address:

Citizenship:

Post Office Address:



47 Stearns Street, Newton, MA 02159

United States

47 Stearns Street, Newton, MA 02159

Date: 3/21/00

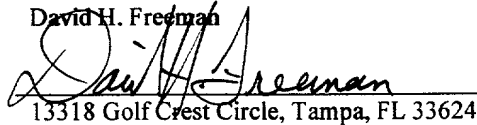
Full Name of Inventor: David H. Freeman

Inventor's Signature:

Residence Address:

Citizenship:

Post Office Address:



13318 Golf Crest Circle, Tampa, FL 33624

United States

13318 Golf Crest Circle, Tampa, FL 33624

Date: 3/2/2000